Optimization of Biogas Production and Use for Des Moines, IA

Presented by Scott Carr, P.E.

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Agenda

• Background
• High-strength organic waste receiving and conveyance
• Managing foam production
• Mixing digester contents
• Managing increased biogas production
Des Moines Wastewater Reclamation Authority

- City of Des Moines is contract operator of the Wastewater Reclamation Facility (WRF)
- Serves 17 member agencies over three counties
- Average dry weather flows of 67 MGD
- Preferred hauled waste facility for Iowa and surrounding areas
WRF Facilities

67 MGD

Primary & Secondary Treatment

Hauled Wastes

0.14 MGD

• >30 loads/day
• ~45% of VS load

Anaerobic Digestion

Biogas Storage

Sludges

Biogas Uses

• Process Heating
• Building Heating
• Power Generation
• Industrial User

Biosolids to Land Application
Des Moines WRF
Existing Digestion and Hauled Waste Facilities
A Wastewater and Organic Waste Treatment Center
Hauled Wastes

- **Examples:**
  - *Fats, oils and grease (FOG)*
  - *Food / animal processing wastes*
  - *Biodiesel / ethanol byproducts*

- **Issues:**
  - *Spikes in biogas*
  - *Foaming*
  - *Pipe blockages*

- **Received 24/7!**
Hauled Waste Program Provides a Valuable Service to Multiple Stakeholders

• Value of Hauled Waste Program to WRA
  – *Generates > $1.5 million annually in hauled-in waste tipping fees*
  – *Diverts FOG from collection system*
  – *Biogas for beneficial use*
    • Produce ~1,300,000 cf/day
    • Generate electric power (1.8 MW existing, expanding to 4.8 MW)
    • Heat 3 plant boilers
    • Sell ~ 700,000 cf/day (>2.0 million revenue since 2007)

• Valuable service to industries
  – *Receive wastes at competitive prices*
  – *Provide FOG haulers with outlet*
  – *Provides low cost energy to neighboring industry*

• Revenues help lower costs to rate payers
WRF – Regional Hauled Waste Center
Monthly Trucks Unloading at the WRF
WERF Research Shows Value of High-Strength Wastes

- Evaluate value of different wastes
- Evaluate alternative loading parameter
FOG (from restaurants) Hauled to WRF
Hauled Waste Upgrade – 2005

Original Hauled Waste Facility

- No storage
- No method of measuring loads
- Direct feed to digesters
- Difficult to manage thick wastes
New Receiving/Storage

• 170,000 gallons of storage
• Controlled feed to digesters
• Can “homogenize” difficult wastes
• Can isolate before digestion
• Includes scales for measurement and billing
New 170,000 Gallon Receiving Tank
New Receiving/Storage Tank

- Mixed via recirculation pumps and nozzles
- Lined for corrosion control
Receiving Tank Helps with Management of Highly Variable Characteristics of Wastes

- Variable consistency
  - High solids
  - High temperature loads (50 to 200 °F)
- Corrosive conditions
  - pH, 3.5–12
- VS, 32 to 99%
- Oil and grease, <1,000 –125,000 mg/L
Debris in Hauled Wastes
Scales Used for Waste Measurement and Billing

2013 Rates

- **In-Service Area Rate:** $0.015866/lbs. ($0.1323/gallon)

- **Out-of-Service Area Rate:** $0.023799/lbs. ($0.1985/gallon)

- **Fats, Oil, and Grease Rate:** $0.001861/lbs. ($0.0155/gallon)
2005 Hauled Waste Upgrade Results

• Advantages
  – *Tanker unloading time reduced by 50%*
  – *Areas of congestion eliminated*
  – *Customers ( haulers ) give positive comments*

• Disadvantages
  – *Single tank = difficult to clean*
  – *Cleaning interrupts customers*
Hauled Waste Upgrade - 2010

- Small (~1200 gal) “rock-boxes”
- Precast polymer concrete
- 4” & 6” quick-connects
- Connection to existing foul air system
- Traps grit/debris before larger tank
New Receiving Boxes

• HDPE / PVC sheet type liners
  – Can be retrofitted to existing tanks
  – Risk of delaminating at seams
  – Heat sensitive

• Polymer pre-cast concrete
  – Uses resin as a binder instead of Portland cement
  – Corrosion barrier is intrinsic to material (no concerns about delamination)
  – Good for new construction (pre-cast structures)
  – Higher capital costs
New Receiving Boxes
Managing Foam Production

• High-strength wastes can increase foam production
  – *Rapid breakdown*
  – *Constantly changing feed characteristics*

• Foam disrupts digestion operation
  – *Mess for operators*
  – *Can impede biogas collection*
  – *Can affect structural integrity*
Managing Foam at WRF – Submerged Fixed Concrete Covers Selected for Primaries

- Concentrate scum and foam at central point
  - Allows spray suppression to be more effective
  - Large diameter draw-off for rapid removal

- Additional benefits
  - Ease of maintenance
  - Increase in tank capacity (8%)
Submerged Fixed Cover Gas Dome

- Gas Withdrawal
- Gas Dome
- Spray Nozzles
- Emergency
- Liquid Level
- Overflow to Standpipe
- Normal Overflow to Standpipe (Embedded in Cover)
- Recirculation from Tank Bottom
- Transflow
- 3-Way Valve
- Pressure Vacuum Relief
- Gas Withdrawal
- Gas Dome
- Emergency Overflow Pipe to U-Tube Gas Seal
- Normal Operating Level
New Submerged Fixed Covers
New Submerged Fixed Cover
New Gas Membrane Cover
Mixing System Considerations

**Typical Digestion Mixing Systems**

- **Gas Bubble**
  - Low energy input
  - Bottom-to-top pattern
  - Maintenance issues

- **Mechanical**
  - Low energy input
  - Top-to-bottom pattern
  - Maintenance issues

- **Pumped Recirculation**
  - High energy input
  - Highest induced velocity
  - Tangential swirl pattern
  - Suitable for diverse covers
Computational Fluid Dynamics (CFD) Modeling

- Mechanical Mixing
- Gas Mixing
- Pumped Mixing

Pathlines colored by velocity (fps)
Computational Fluid Dynamics (CFD) Modeling

• Recommended 24-inch diameter draft tubes

• Cost Savings:
  – $700K in capital (4% of total project construction cost)
  – $36K/yr in O&M (800,000 kWh/yr in energy consumption)
Draft Tube Mixers
Managing Biogas Production

Eliminate Waste!
Storage Does not Equate to Use!

Existing Storage
Flare ~5%

Old
145,000 cf

New
475,000 cf

Expanded Storage
Still Flare ~13% with increased production rate if use not increased
Biogas Production

ACC Digester Gas Produced

Goal of 38,584,556 Cu. Ft.

Year to Date 533,210,901 Cubic Feet
Diversification Increases Use!

Biogas

- Boilers
  - On-site
  - Industry
- I.C. Engines
- Gas Turbines
- Fuel Cells
- Stirling Engines
- Micro-Turbines
- Biomethane
- Vehicle Fuel

Diversification Increases Use!
WRA’s Staged Approach to Expanding Biogas Use

• Increase industry use
  – 700,000 cfd increase to 1,200,000 cfd

• Expand power generation
  – Existing 1.8 MW
  – Added 3.0 MW in 2014

• Expand on-site use in boilers (future)
Process and Economic Model

**Input Parameters**
- Different Hauled-in Wastes
- Digestion Process Parameters
- Power Natural Gas Tip Fees Treatment Costs Land Application Dewatering

**Model**
- Primary & WAS
- Biogas Options

**Output**
- Monthly Biogas Balance
- Present Worth

**Parameters**
- Power
- Natural Gas
- Tip Fees
- Treatment Costs
- Land Application
- Dewatering
Example of Process and Economic Model Output
Rehabilitation for Co-Digestion Enhanced the WRF’s Overall Sustainability

- Reliable systems provide valuable service to industries
- Increased revenue
- On-site power production provides greater reliability
- Flexibility for multiple energy uses
Thank You
Scott Carr (CarrJS@cdmsmith.com)